Regional Operational Plan SF.3F.2014.12

Copper River Chinook Salmon Smolt Abundance–Coded-Wire Tagging Phase, 2015–2016

by

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May 2015

Alaska Department of Fish and Game | Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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SIGNATURE/TITLE PAGE

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Plan Type:	Category III

Approval

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PURPOSE

The Copper River is 1 of 12 indicator stocks chosen by the ADF&G in the *Chinook Salmon Stock Assessment and Research Plan* (ADFG Chinook Research Team 2013) as a stock for which additional information on stock productivity is desired, and the lack of estimates of juvenile abundance and survival for this stock has been identified as an information gap. Furthermore, age-structured production models that are widely used to understand a stock's dynamics require information about processes like recruitment and mortality. To better understand these processes, Region III Sport Fish Division plans to conduct a coded wire tag (CWT) study to estimate the annual abundance of Chinook salmon smolt emigrating from the Copper River and their subsequent marine survival. The project is designed as a two-event mark-recapture study where marked Chinook salmon smolt migrating to sea constitute the first event and returning adult salmon examined in the commercial harvest and in fish wheels used to estimate escapement constitute the second event. This operational plan describes the marking portion of the study for brood year (BY) 2013 and 2014. Four crews will sample in the spring of 2015 using multiple gear types to catch and mark BY 2013 Chinook salmon smolt with CWTs as they migrate from the Copper River in 2015. Chinook salmon from BY 2014 will be captured and marked in fall 2015 while rearing in Copper River tributaries and will also be marked as smolt when they migrate to sea in spring 2016.

BACKGROUND

The Copper River Chinook salmon population supports significant commercial, subsistence, personal use, and sport fisheries. The average annual Chinook salmon harvest from 2003–2012 was 25,071 fish in the commercial fishery, 3,532 fish in the subsistence fisheries, 2,513 fish in the personal use fisheries, and 3,139 fish in the sport fisheries (Somerville 2014). Since 1999, the Copper River drainage has sustained an average run of ~ 71,000 Chinook salmon; however, in recent years the run has declined to an average of ~ 54,000 Chinook salmon. A drainage-wide sustainable escapement goal of >24,000 Chinook salmon was established in 2002 based on the average of escapement estimates from 1980–1998 derived from a catch-age model (Savereide 2004). A mainstem mark-recapture project has been in place since 1999 that along with harvest estimates is used to generate annual estimates of escapement and total run size. These estimates will ultimately be used to construct a spawner recruit model to derive a more biologically-based spawning escapement goal, but to date, the data are insufficient.

The Copper River Chinook stock is composed of 6 major spawning stocks (Upper Copper, Gulkana, Tazlina, Klutina, Tonsina, and Chitina), and 6 years of radiotelemetry studies suggest no spawning occurs downstream of the Chitina River located approximately 170 km upstream from the mouth of the Copper River (Savereide 2005) (Figure 1). Although it is unknown whether juvenile Chinook salmon overwinter in the mainstem Copper River prior to smolting, it is reasonable to assume that all waters downstream of the Chitina River confluence contain a mixture of fish from all spawning stocks. Ice-out in the Copper River progresses from upstream to downstream such that the stretch of river immediately downstream from the Chitina River is ice free approximately a week to ten days before the channels in the Copper River Delta.

Pilot sampling performed in 2014 indicated that both the Copper River near Chitina and the Copper River Delta, as well as tributaries upriver from Chitina, provided capture opportunities for Chinook Salmon smolt from mid-May through early June. Although capture rates in 2014 were below what would be needed to successfully produce smolt abundance estimates with desired levels of precision, it is believed that experience gained in 2014 and increased effort in 2015 create a reasonable likelihood of capturing and tagging adequate numbers of Chinook salmon smolt. As such, tagging efforts undertaken in 2015 will include expanded sampling periods, greater fishing effort and a variety of gear types to maximize the chances of success.

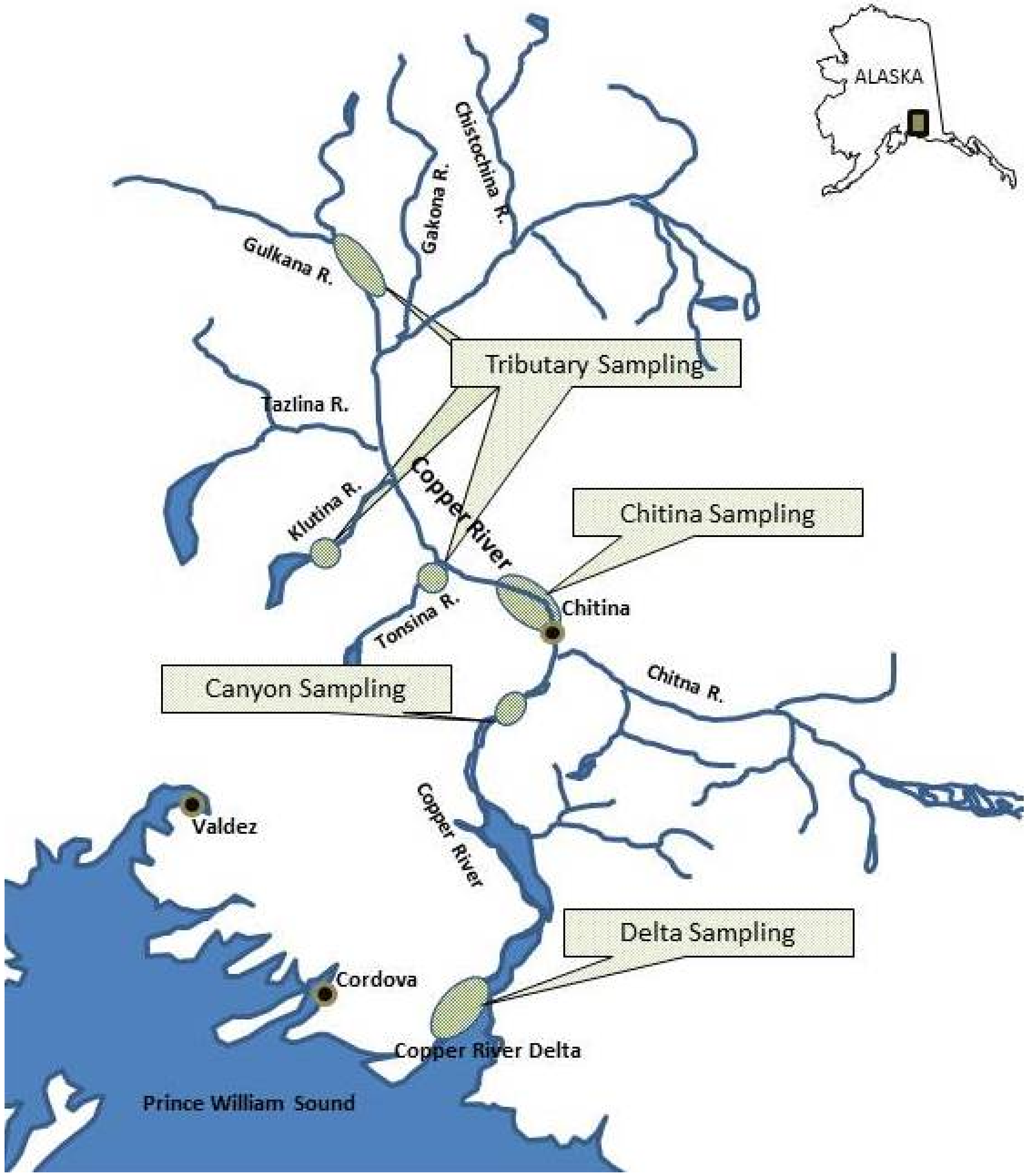

Figure 1.–Map of spring sampling areas in the Copper River drainage.

Additionally, a fall tagging event will be conducted to capture rearing juvenile Chinook salmon parr that will ultimately smolt in 2016.

OBJECTIVES

The objectives for 2015 are:

1. Capture and coded-wire tag (CWT) 30,000 Chinook salmon smolt from BY 2013 in the Copper River drainage in 4 sampling locations and time periods during the spring smolt migration. Sampling areas (Figure 1) and time frames include:
    a. Tonsina, Klutina, Gulkana and Chistochina rivers from ice-out through June using minnow traps;
    b. Mainstem of the Copper River above its confluence with the Chitina River from ice-out through mid-July using minnow traps and fyke traps;
    c. Mainstem of the Copper River near Canyon Creek from ice-out through mid-July utilizing an inclined plane trap and rotary screw trap; and,
    d. Copper River Delta near the 25-Mile Bridge outside of Cordova, utilizing beach seines from June 1 through mid-July;
2. Evaluate catch per unit efforts and run timing for all areas and determine the most effective capture methods for spring 2016 tagging efforts; and,
3. Capture and coded-wire tag 40,000 Chinook salmon parr (BY 2014) in the Copper River drainage during the fall (late August through early September) utilizing baited minnow traps. Areas to be targeted will include the Tonsina, Klutina, Gulkana, Chistochina, and Chitina rivers (Figure 2).

Although not an objective for this operational plan, returns of coded wire-tagged Chinook salmon smolt in the commercial fishery in 2016 through 2020 will be used to estimate smolt abundance migrating from the drainage in 2015 and marine survival for BY 2013. Parr from BY 2014 tagged in the fall of 2015 will contribute to the total number of smolt tagged in spring 2016 and will be used to estimate overwinter survival of parr in winter 2015–2016, smolt abundance in 2016, and marine survival for BY 2014.

METHODS

The purpose of CWTing juvenile Chinook salmon in the Copper River is to employ a two-event mark-recapture experimental design to estimate the abundance of Chinook salmon smolt migrating from the Copper River drainage utilizing the number of marked Chinook salmon smolt as the first event and the examined adult Chinook salmon returning to the drainage as the second event. Juvenile Chinook salmon from BY13 will be tagged as they migrate from the drainage in 2015 (spring sampling) and adults will be examined when they return in 2016–2020. Juvenile Chinook salmon from BY14 will be marked in the fall of 2015 and during their smolt migration in spring 2016 and will be examined for marks when the adults return in 2017–2021. This operational plan describes the capture and marking of juvenile Chinook salmon from BY 2013

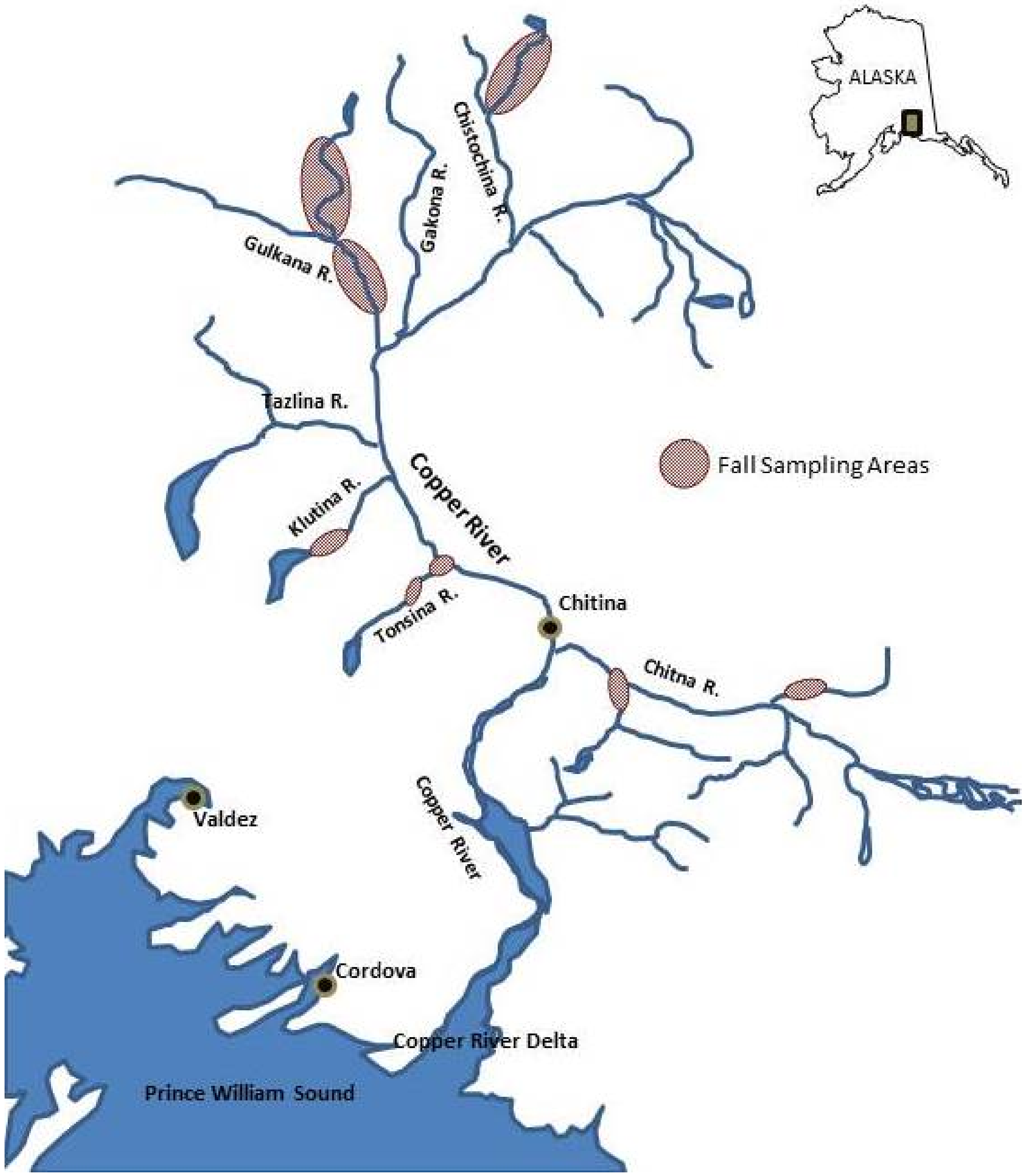

Figure 2.–Map of fall sampling areas in the Copper River drainage.

and 2014 and will discuss adult sampling in reference to data analysis and sample size considerations. A later operational plan will describe the methodology for adult sampling in 2016–2021.

SMOLT AND PARR TAGGING

Spring 2015 and 2016 Chinook Salmon Smolt Sampling

The Copper River is a glacially dominated system located in Southcentral Alaska and is the second largest river in Alaska in terms of average discharge. Ice and/or snow conditions during the spring salmon smolt outmigration may preclude effective sampling of Chinook smolts due to the impracticality of sampling through the ice and/or safety concerns during periods with large ice- flows. Currently, there is no concrete information on the outmigration timing of Chinook salmon smolts from the Copper River, but pilot research in the drainage in 2014 indicated that migration of Chinook salmon was minimal at ice-out and picked up steadily until early June when sampling ceased. Additionally, fish were still present in the Tonsina River tributary into early June. Studies on the Taku and Stikine rivers in Southeast Alaska have not encountered fish migrating prior to ice-out and consistently produce relatively precise estimates of abundance (Pahlke et al. 2010).

Four crews of 3 people will sample 4 different areas for 6 to 8 weeks in each of the assigned sampling areas during the 2015 spring season. One crew (the Tributary Crew) will sample the 4 most accessible (and largest contributors based on spawning populations) tributaries in the drainage, one crew (the Chitina Crew) will sample the mainstem of the Copper River above its confluence with the Chitina River, one crew (the Canyon Crew) will sample at Canyon Creek below Wood Canyon in the mainstem Copper River, and the fourth crew (the Delta Crew) will sample on the Copper River Delta (Figure 1). All Copper River stocks will be subject to capture by the Canyon and Delta Crews as those crews will be positioned below all known spawning and likely rearing areas. All stocks other than the Chitina River stocks will be subject to capture by the Chitina Crew while the Tributary Crew will only sample the Tonsina, Klutina, Gulkana and Chistochina stocks.

The Tributary Crew will sample the Lower Tonsina River, the Klutina River below Klutina Lake, the Gulkana River, and the Lower Chistochina River on a rotating basis from ice-out through June 30 (or later, if ice-out occurs later than mid-May). The Lower Tonsina and Chistochina rivers will be accessed by foot while the Klutina and Gulkana rivers will be accessed by jet boat. The crew will fish 4 trap nights in each location before rotating to the next tributary. The crew will deploy 80 to 100 minnow traps baited with cured salmon roe and will check traps daily. Minnow traps will be deployed along multiple channel banks and in backwater areas. Areas of woody debris will be targeted when present and traps will be checked and rebaited daily and moved to a new location if catches are low.

The Chitina Crew will be deployed after ice-out in the mainstem of the Copper River above its confluence with the Chitina River. The Chitina Crew will sample the braided section of river above and around the airport utilizing 100 baited minnow traps and 4 small fyke traps from ice-out through mid-July. In 2014, fishing effort indicated that juvenile Chinook salmon were most commonly caught in shallow side channels running along the margins of the river and through islands. Small fyke traps (27” x 39”, ¼” mesh with 25’ leads) may be an effective method for capturing fish in these channels. Fyke traps will be deployed in shallow channels where the cod end can be positioned in sheltered, eddying areas to protect captured fish. Fyke traps and minnow traps will be moved to appropriate habitat as rising water levels dictate.

The Canyon Crew will operate a rotary screw trap and an inclined plane trap (Todd 1994) below Wood Canyon near Canyon Creek. Traps will be positioned along the inside bend of the river where NVE operates its upper fish wheel for capturing adult salmon (van den Broek et al. 2010). These traps will be operated from ice-out through mid-July and as water conditions allow. The Copper River is greatly constricted through this area and the turbulent water and high flow rates likely makes migrating smolt subject to capture by passive gear, particularly if they favor the less turbulent water along the beach side of the river. In 2014, beach seining effort in this area indicated that juvenile Chinook salmon were present but it was not feasible due to the size of the substrate and the damage caused by this substrate to the juvenile salmon when retrieving the seine. Both traps will be anchored at the lower end of the bend in the river to reduce the amount of debris encountered. Traps will be anchored by deadman and duckbill anchors driven into the beach and supported by spar logs. Anchors will be secured such that traps can easily be repositioned as rising water levels dictate. Traps will be fished in such a manner that the lower part of the trap lays just above the bottom of the river. Traps will be checked and cleaned a minimum of twice a day. When water levels are rising, the rotary screw trap will be monitored in the evening so that the screw can be raised to avoid large and heavy debris loads.

The Delta Crew will operate from June 1 through mid-July (with dates open to shifting based on capture rates at other locations) on the Copper River Delta near the 25-Mile Bridge similar to operations in 2014. Beach seines will also be used to capture emigrating Chinook salmon smolts just as Southeast Alaska smolt studies have done since 2002 (Richards et al. 2008). In 2014, beach seining effort in this area indicated that juvenile Chinook salmon were present but catches were low from ice-out until the first week of June, when sampling ceased due to monetary concerns but catches were starting to improve. Seines are 60 to 80 ft long and 6 ft deep with ¼" knotless mesh dyed "fish green." Seines will be deployed by hand along multiple channel banks within each area each day. Beach seines will be fished a set amount of time each day, between 15 and 20 seine hauls depending on conditions.

Results from 2015 spring sampling and the success of 2015 fall sampling will be used to determine how effort will be increased, decreased, or shifted in spring 2016. It is anticipated that successful sampling of fall parr in 2015 will reduce the number of smolt that need to be captured and marked in 2016 and that further experience in spring sampling in 2015 will lead to improved sampling methodology.

Fall 2015 Chinook Salmon Parr Sampling

Five tributaries will be sampled between August 15 and September 15, 2015 to capture and mark rearing BY 2014 Chinook salmon parr. Crews of 2 people will spend 2 weeks sampling in each of 5 tributaries; the Tonsina, Klutina, Gulkana, Chistochina and Chitina rivers (Figure 2). Based on sampling in the late 1990s it is expected that the Tonsina, Klutina, Gulkana and Chistochina rivers will produce approximately 48,000 juvenile Chinook salmon large enough (> 50 mm FL) for coded wire tagging (Sarafin 2000). The Chitina River has never been sampled and 2015 will include pilot efforts in this portion of the drainage. Crews will fish approximately 80 minnow traps per day.

The Tonsina River will be accessed by foot at 2 locations. The Lower Tonsina River will be sampled up and down river from the Edgerton Highway bridge and in the braided section where the river runs alongside the Richardson Highway south of the village of Tonsina (Milepost 65–74). The first 4 miles of the Klutina River will be sampled by jet boat from the Klutina Lake mouth downstream. The Gulkana River will be sampled by a combination of rafting and jet boat. The upper section of the Gulkana River will be sampled by floating from Paxson Lake to the Sourdough campground on the Richardson Highway over the course of one week. The lower portion of the Gulkana River will be sampled by jet boat. The East Fork Chistochina River will be sampled by float trip from Mankomen Lake to the Tok Highway bridge. The Chitina River will be sampled by foot and jet boat in the lower reaches of the Tebay River and by foot in Lakina Creek where it intersects with the McCarthy Road.

Jet boat and foot crews will operate out of central locations where the tagging camp will be located. All captured fish will be transported to the tagging camp in aerated totes and held in net pens and live-wells in the river while waiting and recovering from tagging. Tagged fish will be transported back to the general areas where they were captured and released in areas where structure is available for cover and feeding. Float crews will seek habitat structure indicative of salmon habitat (moderate flow, large woody debris and other structure) while moving down river. When candidate areas are found the crew will test fish 10 minnow traps for an hour to see if Chinook salmon parr are present. If fish are present the crew will deploy all 80-100 traps by foot and set up camp for the evening.

Coded Wire Tagging

Chapell (2013a-b) developed nonlethal CWT marking and detecting methodology to increase the sample size of CWT detections from the Chilkat River by brood year and by fall or spring marking. Releasing smolts in the spring with a second CWT beneath the dorsal fin in addition to one in the snout allowed for the use of a hand-held wand to sample the adult return. The presence/absence of the second CWT combined with an age determined by scale analysis identified adipose-clipped fish as marked in the fall or spring of a particular brood year. This methodology will be used to derive estimates of parr and smolt abundance, overwinter survival, and marine survival.

All captured Chinook salmon in spring and fall 2015 sampling that have not already been tagged (as indicated by a clipped adipose fin) and are greater than 50 mm FL will be injected with a CWT following the methods of Koerner (1977). Prior to marking, fish will be anaesthetized in a solution of Aqui-S 20E as per the manufacturer's indications. Anaesthetized fish will be identified to species with non-Chinook salmonids excluded from tagging. Chinook salmon juveniles will be marked externally by excision of the adipose fin. In the spring every 20th fish will be measured to the nearest mm FL and weighed to the nearest 0.1 g while in the fall every 100th fish will be measured to the nearest mm FL. Each CWT is formed by cutting a 1.1 mm section of wire from a spool stamped with a unique numeric code. Different codes will be utilized for fall and spring tagging. The tag will be injected into the snout utilizing the MKIV Tag Injector (Northwest Maine Technologies, Inc.) and fish checked for successful tagging by passing the fish through a V-Detector that detects the presence of the embedded CWT.

In spring of 2016 (when BY 2014 fish undergo their smolt migration), untagged Chinook salmon smolt will be given a secondary CWT (CWT2) inserted in the muscle tissue at the base of the dorsal fin. This will ultimately allow handheld wand CWT detectors to distinguish spring-tagged fish from fall-tagged fish during the adult returns without sacrificing fish. Because there has been no fall tagging of BY 2013 fish it will not be necessary to double tag in the spring of 2015. However, the fall tagging of BY 2014 fish in 2015 will necessitate double tagging in the spring of 2016 and in subsequent years as the project continues.

All marked fish will be held overnight to check for 24 hour tag retention and handling induced mortality. The morning after tagging, the first 100 fish will be checked for CWTs utilizing the V detector and all mortalities will be recorded. If tag retention is greater than 98% mortalities will be counted and all live fish will be released. If tag retention is less than 98% all fish will be rechecked and those without tags will be retagged. The total number of fish tagged, the number of mortalities, and the number of fish that shed their tags will be recorded and submitted to the DCG Tag Lab at the completion of the field season. In addition, the number of already tagged fish encountered will be recorded.

In spring 2016 when smolt are double-tagged a wand detector will be used to determine tag retention in both locations (snout and dorsal). The snout will be contacted with the marked side of the wand and if a tag is detected, the fish will be turned around and the base of the dorsal fin will be swiped with the wand in a similar fashion. If the retention rate during the double tagging event is less than 100% then the entire batch of smolts will be reprocessed and those that test negative will be retagged because it is critical to be able to differentiate between spring and fall tagged fish.

SAMPLE SIZES

Ultimately a two-event mark-recapture experimental design will be used to estimate the abundance of Chinook salmon smolt migrating from the Copper River drainage utilizing the number of Chinook salmon smolt marked as the first event and the examined adult Chinook salmon returning to the drainage as the second event. The precision goal for this project will be to produce smolt abundance estimates with 90% confidence intervals within 25% of the estimate. To do so will require tagging adequate numbers of smolt and examining adequate numbers of adults. Juvenile Chinook salmon from BY13 will be tagged as they migrate from the drainage in 2015 and adults will be examined when they return in 2016–2020. Juveniles from BY 2014 will be marked in the fall of 2015 and during their smolt migration in spring 2016 and will be examined for marks when the adults return in 2017–2021.

The commercial harvest, which has ranged from 9,457 to 18,500 (average = 12,161) between 2008 and 2012 (Somerville 2014) will produce a range of 473 to 588 fish to examine for adipose fin clips and coded wire tags if 5% of the harvest is examined and between 946 and 1,176 fish if 10% of the harvest is examined. In addition to the commercial harvest, the fish wheels used to generate abundance estimates of Chinook salmon escapement in the Copper River drainage will provide approximately another 2,600 to 5,500 fish (average ~4,300 from all fish wheels from 2010–2012) to examine for adipose clips and coded wire tags. While only a portion of these fish will be available for lethal sampling and coded wire tag retention, sampling the escapement for adipose fin clip status, age by scale samples and CWT2 presence/absence is an adequate surrogate for CWT recovery (Chapell 2013a-b). Thus we expect a range of approximately 3,073 to 6,088 fish to be available for inspection for adipose fin clips and CWTs annually if 5% of the commercial harvest is sampled and 3,546 to 6,676 fish if 10% of the commercial harvest is sampled. This level of sampling effort each year over the entire brood year return (age .1 through age .6) will likely equate to at least 3,000 to 6,000 individuals from a particular brood year being examined for tags.

The Stikine River drainage, which is smaller in size but relatively similar in flow and escapements to the Copper River, supports a Chinook salmon population that averaged 112 smolts per spawner from 1998 through 2002 (Pahlke et al. 2010). Assuming 100 smolts per spawner and an average escapement of 30,000 in the Copper River, the number of smolts annually emigrating from the Copper River would be approximately 3,000,000. Based on the above sampling scenario, inspecting 3,000 adults per year would necessitate tagging 24,962 Chinook salmon smolt, sampling 4,000 adults per year would require marking 18,755 smolt, and sampling 5,000 adults would require marking 15,017 smolt to achieve the desired precision (35% at 90% confidence) on smolt abundance estimates (Robson and Regeir 1964).

For BY 2013 salmon only spring tagged smolt will be available for generating abundance estimates. Based on capture rates from the 2014 pilot study we anticipate that the Chitina and Tributary crews will be able to capture and mark over 6,272 smolt using minnow trap and the Delta Crew will be able to capture and tag 1,190 fish by beach seine. We believe these numbers are very conservative given that the pilot season occurred during the beginning of the smolt migration and that this was the first attempt to capture Chinook salmon smolt in the Copper River drainage. If 4 fyke traps operated by the Chitina Crew can produce an average of 15 Chinook salmon per trap per day, 3,360 Chinook salmon smolt would be tagged which brings the total number to 10,823 smolt. Based on adult sample sizes of 4,000, 5,000 and 6,000 the inclined plane trap and screw trap would have to produce 14,739 (246 smolt per day), 8,383 (140 smolt per day) and 4,557 (76 smolt per day) respectively to achieve sample size goals. While the largest sample size will likely be difficult to achieve, the lower two estimates should be reasonable goals considering experience gained in 2014 and greater fishing effort to be expended in 2015.

Fall sampling in 2015 will be for BY 2014 Chinook salmon. Based on CWTing efforts in 1997–1999 (Sarafin 2000) it is anticipated that 48,000 parr will be captured and marked with CWTs in 2015. Assuming an average overwinter survival rate of 30% as seen in the Chilkat River (Chapell 2013a-b), 16,000 of those would survive to smolting. The success of fall tagging in 2015 will determine how much effort needs to be expended in spring 2016 to achieve sample size goals. Anticipated numbers and greater experience garnered in spring 2015 sampling should ultimately make this project feasible.

Data Collection

The following data will be collected and recorded for each set of minnow traps, beach seine set, fyke trap, inclined plane trap and rotary screw trap:

1. Trap number (or seine set number);
2. Set date and time (and pull date and time for minnow traps);
3. GPS coordinates of each group of traps or set;
4. Total catch of Chinook salmon;
5. Total catch of other species (listed individually).

The following will be recorded daily in the CWT daily log:

1. Date
2. Location (crew, tributary/area)

3. CWT Code
4. Air Temp minimum and maximum
5. Water Temperature
6. Water Depth
7. Number of Chinook Salmon tagged
8. Number of Recaptured Chinook Salmon (already tagged and adipose clipped). All recaptured fish will be checked for tag retention and, in spring 2016, tag location.
9. Starting Number on MKIV CWT machine
10. Ending Number on MKIV CWT machine
11. Number of retags (fish that needed more than one CWT)
12. Post tagging mortalities
13. Number of mortalities after 24 hour holding
14. Number of Tag sheds after 24 hour holding
15. Total Number of CWT'd Chinook salmon released after 24 hour holding

Additionally, the length (FL) to the nearest mm and weight (spring only) to the nearest 0.1 g of every 20th (spring) and 100th (fall) fish will be recorded.

Data Reduction

During the fieldwork, all data will be recorded into all-weather field notebooks or on data forms printed on all-weather paper. Following the fieldwork, data will be transcribed into an Excel workbook spreadsheet from which all data analysis will be referenced and performed. The electronic files will be submitted upon completion of the final report and placed into the Division's Intranet Docushare website – the file name and directory location will be presented in the final report. The spreadsheet will also be archived with the ADF&G Research and Technical Service (333 Raspberry Road, Anchorage, AK 99518) when completed.

DATA ANALYSIS

Catch Per Unit Effort

CPUE summary statistics will be calculated for each area and each gear type for the following categories:

1. by entire sampling period;
2. by day to examine for temporal patterns; and,
3. by bank/channel (east/west or middle/side) to examine spatial patterns.

CPUE will be estimated as a ratio (Cochran 1977) by the desired time period (e.g., hour, day, week, or entire period), gear type, and bank/channel as:

$$CPUE_{g,t,l} = \sum_{d=1}^{n_{g,t,l}} c_{g,t,l,d} \Bigg/ \sum_{d=1}^{n_{g,t,l}} s_{g,t,l,d} \tag{1}$$

with variance:

$$\hat{V}(CPUE_{g,t,l}) = \frac{n_{g,t,l}\sum_{d=1}^{n_{g,t,l}}\left(c_{g,t,l,d}^2 - 2CPUE_{g,t,l}c_{g,t,l,d}s_{g,t,l,d} + CPUE_{g,t,l}^2 s_{g,t,l,d}^2\right)}{(n_{g,t,l}-1)\left(\sum_{d=1}^{n_{g,t,l}} s_{g,t,l,d}\right)^2} \quad (2)$$

where:

$c_{g,t,l,d}$ = catch using gear g during time period t at location l for observation d (d=1 to $n_{g,t,l}$);

$s_{g,t,l,d}$ = fishing time using gear g during time period t at location l for observation d; and,

$n_{g,t,l}$ = number of observations for gear g during time period t at location l .

CPUE statistics will be examined graphically and compared by inspection to evaluate logistical similarities and differences between gear and temporal periods. CPUE statistics for combinations of catch categories or temporal periods will be calculated using equations 1 and 2 and substituting the appropriate sample size for $n_{g,t,l}$. Comparisons of CPUE statistics between gear or time periods will be performed using a t-test with appropriate variance formulas for non-independent ratio estimates (Cochran 1977).

Brood Year 2013 Smolt Abundance

The abundance $\hat{N}_s$ of BY 2013 Chinook salmon smolts will be estimated using Chapman's modification of the Petersen Method (Seber 1982:60):

$$\hat{N}_S = \frac{(n_C+1)(n_e+1)}{(m_e+1)} - 1 \quad (10)$$

$$var[\hat{N}_S] = \frac{(n_C+1)(n_e+1)(n_C - m_e)(n_e - m_e)}{(m_e+1)^2(m_e+2)} \quad (11)$$

where n_c is the number of valid CWTs (on fish that survive 24 hrs) placed in smolts during the spring, n_e is the number of returning adults from brood year 2013 examined in the escapement and marine harvests from 2016 through 2020 that are successfully aged and found to have been smolts that emigrated from the Copper River during the spring of 2013, and m_e is the subset of n_e with successfully decoded CWTs placed at that time.

Fish sometimes lose their CWTs, CWTs can be lost from recovered heads, and CWTs can be unreadable. If any of these conditions occur, the estimators (equations 10 and 11) must be modified to compensate for the lost marks/CWTs (i.e., loss of m_e). This will be accomplished by adding a term $\lambda = a / t'$ (an overall rate for recovering and decoding CWTs, where a = number of adipose-finclipped fish sampled and t' = number of CWTs decoded) to the denominator of the jLincoln-Petersen/maximum-likelihood estimator, i.e., $\hat{N}_S^* = n_c \; n_e \; / \; m_e \, \lambda$. Variance of $\hat{N}_S^*$ will be estimated using a Monte-Carlo simulation if a suitable closed form estimator is not identified. Although the Lincoln-Petersen estimator is not unbiased, the bias should be negligible in this experiment because the numbers of fish marked, inspected, and recaptured are not small (Seber 1982).

The conditions for accurate use of the M-R method for both species/experiments are:

1. all smolts/parr have an equal probability of being marked; *or*
2. all adults returning to the Copper River have an equal chance of being inspected for marks; *or*
3. marked fish mixed completely with unmarked fish in the population between years; *and*
4. there is no recruitment to the population between years; *and*
5. there is no trap-induced behavior; *and*
6. fish do not lose their marks and all marks are recognizable.

All sampling gear will be operated continuously during smolt emigrations, and returning adults will be sampled continuously in fish wheel catches and in the commercial harvest. A possible late start in tagging projects, periodic sessions of high water, or varying outmigration timing in the spring could cause temporal changes in probabilities of capture. However, these vagaries are troublesome only if migratory timing of smolt from different stocks within the Copper River mimics that of returning adults <u>and</u> these vagaries are coincident in the migratory pattern for both adults and smolt. If migratory patterns of smolt are different than that of adults, marked and unmarked smolts are completely mixed in the population prior to their return as adults. We will test for temporal changes in the fraction of adults missing adipose fins: if at least one of the conditions has been met, this fraction will not change with time. Temporal changes in these fractions will be tested against a χ^2 distribution. Although fish wheels and gillnets can be size selective, their size selectivity should not be a problem because there is no relation between the size of a smolt (when marked) and the size of the returning adult (when recaptured). Because almost all surviving smolt return to their natal stream as adults to spawn, there will be no meaningful recruitment added to the population while they are at sea. Trap-induced behavior is unlikely because different sampling gears will be used to capture smolt and adults. Results from other studies (Elliott and Sterritt 1990; Vincent-Lang 1993) indicate that excising adipose fins and implanting CWTs will not increase the mortality of marked salmon.

Brood Year 2014 Parr and Smolt Abundance

During Copper River Chinook salmon escapement and marine harvest sampling, when BY 2014 heads are taken and CWTs are recovered by the CF Mark, Age, and Tag Laboratory (Tag Lab), the handheld wand scan result for CWT2 presence/absence will be compared with the season tagged determined by CWT code. A correct determination of season tagged by the wand method will be defined as either detected presence of the CWT2 in spring-tagged fish, or the detected absence of the CWT2 in fall-tagged fish.

To assess the accuracy of the wand scan method, all available years of handheld wand scan results will be tallied by correct, false positive, or false negative CWT2 detections. The rate of false positive (ω_{f+}) and false negative (ω_{f-}) identifications will be used to adjust the error associated with estimates of spring-tagged and fall-tagged fish in the BY 2014 return. To assess sampling bias by body size, numbers of correct and incorrect CWT2 detections for large (≥660 mm MEF) and medium/small (<660 mm MEF) will be compared using χ^2 tests.

A statistical model will be fit to the BY 2014 data to estimate the number of parr rearing in fall 2015 (N_{PARR}), the overwinter survival to spring 2016 (ϕ_I), the number of smolts emigrating in 2016 (N_{SMOLT}), and the false negative (ω_{f-}) and the false positive (ω_{f+}) error rates. The number of fish assigned to fall and spring marking events among all BY 2014 Chinook salmon sampled in the Copper River in 2017–2021 will be modeled as having a multinomial distribution with parameters π_1, π_2, π_3, π_4, and C, where:

$\pi_1 = ((1 + \omega_{f+})*q_{FALL} - \omega_{f-}*q_{SPRING})*\rho$,
$\pi_2 = ((1 + \omega_{f-})*q_{SPRING} - \omega_{f+}*q_{FALL})*\rho$,
$\pi_3 = (q_{FALL} + q_{SPRING})*(1 - \rho)$,
$\pi_4 = 1 - \pi_1 - \pi_2 - \pi_3$,
$q_{FALL} = M_{PARR} / N_{PARR}$,
$q_{SPRING} = M_{SMOLT} / N_{SMOLT}$, and
$C = R_1 + R_2 + R_3 + R_4$ = the total number of adult BY 2014 Chinook salmon examined for adipose fin clips in the Copper River in 2017–2021, where

R_1 = the number of adipose-clipped adult fish with wand scan result second CWT absent, implying a fall-tagged fish,

R_2 = the number of adipose-clipped adult fish with wand scan result second CWT present, implying a spring-tagged fish,

R_3 = the number of adipose-clipped adult fish with no wand scan result,

R_4 = the number of adult fish without adipose fin clips,

ρ = the proportion of adipose-clipped adult fish that are wand scanned and assigned a fall or spring tagging event,

M_{PARR} = number of CWT-tagged parr released during fall 2015,

M_{SMOLT} = number of CWT-tagged smolts released during spring 2016, and

falseposDorsal = the number of adult fish known to have been CWT-tagged in the fall that had a positive second CWT scan result in 2017–2021,

correct.ID.NoDorsal = the number of adult fish known to have been CWT-tagged in the fall that had a negative second CWT scan result in 2017–2021,

falsenegDorsal = the number of adult fish known to have been CWT-tagged in the spring that had a negative second CWT scan result in 2017–2021,

correct.ID.Dorsal = the number of adult fish known to have been CWT-tagged in the spring that had a positive second CWT scan result in 2017–2021.

The relative proportion of fall and spring CWTs recovered elsewhere (fisheries outside of the Copper River) also contains information about the survival probability ϕ_1. Therefore the number of valid CWTs from the fall 2015 marking event recovered from Chinook salmon sampled elsewhere in 2017–2021 will be modeled as having a binomial distribution with parameters:

$\pi_{FALL} = q_{FALL} / (q_{FALL} + q_{SPRING})$,

and m = number of BY 2014 Copper River Chinook salmon fall and spring CWTs recovered in fisheries outside of the Copper River from 2017–2021.

Bayesian statistical methods, which are well-suited for analyzing unconventional data[1], will be used to estimate the error associated with maximum likelihood estimates. Bayesian methods use probability distributions to express uncertainty about model parameters. The user supplies the "prior" probability distribution, which expresses knowledge about the parameters outside the frame of the experiment itself. The output of a Bayesian analysis is the "posterior" distribution, which describes the new, updated knowledge about the parameters after consideration of the experimental data. Percentiles of the posterior distribution can be used to construct one-sided probability statements or two-sided intervals about the parameters. Point estimates are de-emphasized in Bayesian statistics; however, the mean, median, or mode of the posterior can be used to describe the central tendency of a parameter. The standard deviation of the posterior distribution can be used as an analogue of the standard error of a point estimate in classical statistics.

Bayesian analyses require that prior probability distributions be specified for all unknowns in the model. A normal prior distribution with very large variance will be specified for N_{PARR}, essentially equivalent to a uniform distribution. A beta (1, 1) prior will be used for ϕ_I and a beta (1, 1) prior will be used for ρ. These priors are noninformative, chosen to have a negligible effect on the posterior. Noninformative priors for ω_{f-} and ω_{f+} will also be used given this project is in its first years. For ω_{f-}, and ω_{f+}, a beta (1, 1) prior will be used. Markov-Chain Monte Carlo simulation, implemented with the Bayesian software WinBUGS (Gilks et al. 1994), will be used to draw samples from the joint posterior probability distribution of all unknowns in the model. Three Markov chains will be initiated, a 4,000-sample burn-in period discarded, and 100,000+ updates generated to estimate the marginal posterior means, standard deviations, and percentiles. The diagnostic tools of WinBUGS will be used to assess mixing and convergence. Interval estimates will be obtained from percentiles of the posterior distribution.

Marine Survival

To determine estimates of marine survival for Copper River Chinook salmon, estimates of the total adult return and smolt abundance from a particular brood year are required. The estimate of the total return is simply the escapement plus the harvest of all fish from a particular brood year. Age composition estimates of the escapement provides the information needed to reconstruct the escapement by BY. The fraction θ_j of a particular BY carrying a CWT is determined from fish sampled for CWTs in marine commercial fishery and in the Copper River escapement. Because Copper River Chinook salmon are exploited by several fisheries over several years, harvest from a particular BY will be estimated over several strata that are combinations of time, area, and fishery type.

The contribution of Copper River Chinook salmon stocks to the marine harvests will be estimated by:

$$\hat{r}_{ij}^{Marine} = \widehat{H}_i \left(\frac{m_{ij}}{\lambda_i n_i}\right) \hat{\theta}_j^{-1} , \qquad (18)$$

where $\widehat{H}_i$ is the estimated harvest in stratum i, $\hat{\theta}_j$ is the fraction of stock j marked with CWTs, n_i is the subset of total harvest, $\widehat{H}_i$ examined for missing adipose fins, m_{ij} is the number of decoded CWTs recovered from stock j, and λ_i adjusts for imperfect tracking and decoding of CWTs from

[1] The juvenile abundance data would be difficult to analyze correctly using standard statistical methods.

recovered salmon (Bernard and Clark 1996). Variance of $\hat{r}_{ij}$ will be estimated by means of the appropriate large-sample formulations (Bernard and Clark 1996).

Subsistence, personal use, and sport fisheries occur within the Copper River and are assumed to be all Copper River stock. These fisheries will not be sampled for CWTs thus rendering equation 18 above unsuitable as n_i in the denominator would be 0. Separate programs occur that estimate harvest and age composition in the subsistence and personal use fisheries while harvest in the sport fishery is estimated by the statewide harvest survey. Age composition in the sport fishery will be assumed to be equal to that in the other three fisheries (commercial, subsistence, and personal use). Thus $\hat{r}_{ij}^{InRiver}$ for the subsistence, personal use, and sport fisheries will be equal to the H_i estimates and variances provided in the individual sampling programs mentioned.

The total harvest of Copper River Chinook salmon from all fisheries will be estimated by summing across strata and fisheries:

$$\hat{T} = \sum_i \hat{r}_i \,, \tag{19}$$

$$var[\hat{T}] = \sum_i v[\hat{r}_i] \,, \tag{20}$$

Variance is estimated as the sum of variances across strata (no covariance required) because sampling was independent across start and fisheries.

The total BY return is the harvest plus escapement from all years of the return (ages 1.1 through 1.5) or:

$$\hat{R} = \hat{T} + \hat{S} \,, \tag{21}$$

$$var[\hat{R}] = var[\hat{T}] + var[\hat{S}] \,, \tag{22}$$

The exploitation rate is calculated by:

$$\hat{\mu} = \frac{\hat{T}}{\hat{R}} = \frac{\hat{T}}{\hat{S}+\hat{T}} \,, \tag{23}$$

$$var[\hat{\mu}] \approx \frac{var[\hat{T}]\hat{S}^2}{R^4} + \frac{var[\hat{S}]\hat{T}^2}{R^4} \,. \tag{24}$$

The estimated marine survival rate (smolt-to-age-1.1 and older) and the delta-method approximation of its variance is calculated by:

$$\hat{\phi}_2 = \frac{\hat{R}}{\hat{N}_{SMOLT}} \,, \tag{25}$$

$$var[\hat{\phi}_2] \approx \hat{\phi}_2^2 \left[\frac{var[\hat{R}]}{\hat{R}^2} + \frac{var[\hat{N}_{SMOLT}]}{\hat{N}_{SMOLT}^2}\right]. \tag{26}$$

SCHEDULE AND DELIVERABLES

Results from this project will be summarized in a Fishery Data Series Report for which a draft will be submitted to the Research Supervisor by 1 March 2016. Probable dates for sampling activities are summarized below.

Sampling = (S), Mobilization = (M), Demobilization = (D), Analysis = (A), FDS Report = (R)

Date	Tributary Crew	Chitina Crew	Canyon Crew	Delta Crew	Fall Sampling	Data Analysis/Reports
May 1–15	M	M	M			
Ice-out (~May 15)–June 1	S	S	S	M		
June 1–15	S	S	S	S		
June 16–30	S/D	S	S	S		
July 1–15		S/D	S/D	S/D		
Aug. 15–Sept. 15					M/S/D	
October–November						A
December–March						R

RESPONSIBILITIES

Project Staff and Primary Assignments

Philip Joy, *Fisheries Biologist II.* Project Leader. Responsible for supervision of all aspects of the Copper River Chinook salmon smolt project, managing the project budget, and writing the final report.

James Savereide, *Fisheries Biologist III*. Assistant Project Leader. Responsible for assisting with the supervision of all aspects of the Copper River Chinook salmon smolt project and editing the final report.

Loren St. Amand, *Fish & Wildlife Technician III*. Crew leader. Mobilization, day-to-day project tasks, all aspects of field work, demobilization.

Mark Schlenker, *Fish & Wildlife Technician III*. Crew leader. Mobilization, day-to-day project tasks, all aspects of field work, demobilization.

Chad Bear, *Fish & Wildlife Technician III*. Mobilization, day-to-day project tasks, all aspects of field work, demobilization.

Mark Roti, *Fish & Wildlife Technician III*. Mobilization, day-to-day project tasks, all aspects of field work, demobilization.

Vacant, *Fish & Wildlife Technician III*. Mobilization, day-to-day project tasks, all aspects of field work, demobilization.

Vacant, *Fish & Wildlife Technician II* – Mobilization, day-to-day project tasks, all aspects of field work, demobilization.

Allison Martin, *Fish & Wildlife Technician II* – Mobilization, day-to-day project tasks, all aspects of field work, demobilization.

Vacant, *Fish & Wildlife Technician II* – Mobilization, day-to-day project tasks, all aspects of field work, demobilization.

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Vacant, *Fish & Wildlife Technician II* – Mobilization, day-to-day project tasks, all aspects of field work, demobilization.

Jiaqi Huang, *Biometrician II*. Assist with project design and data analysis.

Matt Evenson, *Fishery Biologist IV.* Final report editing and project support.

BUDGET: (Black text = annual costs, *Blue text = start-up costs*)

Spring Smolt

Line 100:

Tributary Crew

Tech III (Glennallen) 6 weeks, 90 hours OT…	$11,426
Tech III (Glennallen) 6 weeks, 90 hours OT…	$11,426
Tech III (Fairbanks) 6 weeks, 90 hours OT…	$11,706

Chitina Crew

Tech III (Glennallen) 8 weeks, 120 hours OT…	$15,235
Tech III (Glennallen) 8 weeks, 120 hours OT…	$15,235
Tech III (Fairbanks) 8 weeks, 120 hours OT…	$15,607

Canyon Crew

Tech III (Glennallen) 8 weeks, 120 hours OT…	$15,235
Tech III (Glennallen) 8 weeks, 120 hours OT…	$15,235
Tech III (Fairbanks) 8 weeks, 120 hours OT…	$15,607

Delta Crew

Tech III (Fairbanks) 6 weeks, 90 hours OT…	$11,706
Tech III (Fairbanks) 6 weeks, 90 hours OT…	$11,706
Tech III (Fairbanks) 6 weeks, 90 hours OT…	$11,706

Plane and Screw Trap construction

Tech III (Glennallen, step K) 4 weeks …	*$5,543*
Tech III (Glennallen, step B) 4 weeks …	*$4,800*

Line 100 Total………… ……………………………………………… **$172,173**

Line 200

4 Round Trip tickets Fairbanks to Cordova…	$2,000
Lodging, Meals, etc.	$1,190

Line 200 Total………………………………………………………… **$3,190**

Line 300

Ferry Service Valdez to Cordova (2014 expenditures)…	$3,000

Line 300 Total…………………………………………………………**$3,000**

Line 400

Groceries, 12 people for 60 days @$25/day/person…	$18,000
Propane…	$250
Weatherports (AKT&T portable Shelters), 4 @ $2,500 ea…	*$10,000*
Beach Seines, Minnow Traps and Fyke Traps…	$5,000
100,000 CWTs & Headmolds	$5,000
Totes, Pumps, Tables, Holding Pens…	*$2,000*
Generators (x3)…	*$3,000*
Boat Gas…	$4,000
Boat Oil, etc.	$500
Boat Supplies…	$1,500
Boat Repair	$5,000

Line 400 Total……………………………………………………… **$54,250**

Line 500

2 CWT Injectors and 2 V Detectors…	*$53,400*
Inclined Plane Trap Floats/ Screw Trap modifications materials …	*$10,000*
Line 500 Total (Excluding T-wand detectors) ………….…………..	**$63,400**

Spring Total ……………………………………………………..	**$296,013**
One Time Costs …………………………………………	***$88,743***
Annual Costs ……………………………………………	**$207,270**

Fall Parr

Line 100:

Tonsina Crew	
Tech III (Glennallen) 17 days, 30 hours OT…	$4,465
Tech III (Glennallen) 17 days, 30 hours OT…	$4,465
Klutina Crew	
Tech III (Glennallen) 17 days, 30 hours OT…	$4,465
Tech III (Glennallen) 17 days, 30 hours OT…	$4,465
Gulkana Crew	
Tech III (Fairbanks) 17 days, 30 hours OT…	$4,575
Tech III (Fairbanks) 17 days, 30 hours OT…	$4,575
Chistochina Crew	
Tech III (Fairbanks) 17 days, 30 hours OT…	$4,575
Tech III (Fairbanks) 17 days, 30 hours OT…	$4,575
Chitina River Crew	
Permanent Staff…	$0
Permanent Staff…	$0
Line 100 Total…………………………………………………………	**$36,160**

Line 200

Line 200 Total…………………………….………………………	**$0**

Line 300

Charters to access Chistochina and Chitina Rivers	$2,000
Satellite Phone Charges	$500
Line 300 Total…………………………………………………………	**$2,500**

Line 400

Groceries, 8 people for 14 days @$25/day/person…	$2,800
Propane…	$250
4 Portable Tagging Shelters	*$5,000*
Totes, Pumps, Tables, Holding Pens…	*$2,000*
Boat Gas…	$1,000
Boat Oil, etc.	$500
Line 400 Total…………………………………………………………	**$13,050**

Line 500

Line 500 Total (Excluding T-wand detectors) ………………………. **<u>$0</u>**

Fall Total ……………………………………………..……………….. **<u>$51,560</u>**

One Time Costs ………………...…………………………… ***$7,000***

Annual Costs ……………………………………..……………. **$44,560**

<u>CY 2015 Total</u>

TOTAL CY 2015

Spring Smolt Total ……………………………………………..……….. $285,670

Fall Parr Total ………………………………………………..……… **$51,560**

Total CY 2015 …………………………………………………. **$<u>347,573</u>**

One Time, Start-up costs ……………………………………….. *$95,743*

Annual Costs ………………………………………………… $251,830

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